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REMOTE
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DEPARTMENT OF ENERGY

EG&G SURVEY REPORT
EP-U-011
DECEMBER 1981

AN AERIAL RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE

MONTICELLO MILL SITE

MONTICELLO, UTAH

DATE OF SURVEY: SEPTEMBER 1980

Nick Abramish

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PROJECT SCIENTIST: H.A. BERRY
EG&G, INC.
LAS VEGAS, NEVADA

1.0 SUMMARY OF RESULTS

An aerial radiological measuring system was used to survey the area surrounding the Monticello Mill site in Monticello, Utah, in late September 1980. The survey was conducted for the U.S. Department of Energy's Office of Operational Safety by the Department's Remote Sensing Laboratory of Las Vegas, Nevada. The highest measured radiation exposure rates (normalized to 3 feet above the ground) ranged from 70 to 150 μR/h over the Monticello tailings pile.

Natural background exposure rates measured by the aerial system ranged from 14 to 16 μR/h, with an average value of approximately 15 μR/h.

2.0 INTRODUCTION

An aerial radiological survey was conducted over a 9.6 square mile area surrounding the Monticello Mill site. The data were obtained between 23 and 27 September 1980 for the U.S. Department of Energy's Office of Operational Safety (OOS) by EG&G of Las Vegas, Nevada using an MBB BO-105 helicopter.

The OOS conducts radiological surveys at sites and facilities where nuclear operations were formerly conducted for the Government. The purpose of this aerial survey was to provide information to help guide the planning of any future ground-based surveys in the same

vicinity. The survey was flown at an altitude of 150 feet with 250 foot line spacings.

Aerial radiological detection systems average the radiation levels produced by gamma-emitting radionuclides existing over an area of several acres. These detection systems are capable of determining specific radionuclides causing radiological anomalies. However, because of averaging, airborne systems tend to underestimate the magnitude of localized sources as compared to ground-based measurements. The detailed systems and procedures employed in obtaining and processing aerial radiation data are presented in References 1 and 2.

In aerial radiological surveys, the energy of gamma rays, their source concentration, and relative distribution are measured by specialized instrumentation. The results are reported as radiation exposure rates in microroentgens per hour (μR/h) at 3 feet above the ground. The maximum annual radiation dose that could be absorbed through continuous exposure (24 hours a day for 365 days to a constant source of radiation), is expressed in millirem per year (mrem/y), and is obtained by multiplying the exposure rate in μR/h by 8.76. These results apply to external gamma radiation only and do not account for inhalation or ingestion of radioactive materials. The actual amount of radiation absorbed depends on the duration and circumstances of exposure.

3.0 BACKGROUND RADIATION

Background radiation originates from naturally occurring radioactive elements present in the earth (terrestrial radiation) and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium

decay chain, and radioactive potassium. Variable concentrations of these nuclides produce estimated annual background radiation doses at the surface of the earth in the United States of about 15 to 140 mrem/y. These background radiation dose estimates are based on typical instead of continuous exposure conditions. Higher background radiation dose levels (up to 140 mrem/y) are found in western states, primarily in the Colorado Plateau area, and are a result of high uranium and thorium concentrations in surface minerals and increased cosmic radiation because of higher elevation.

The uranium decay chain includes radium-226 and its daughter, radon, which is a noble gas, i.e., it will not combine chemically with other elements. The radionuclide radon can both diffuse through soil and move through the air to other locations. Thus, the level of radiation contributed by this noble gas is dependent upon meteorological conditions, mineral and moisture content and permeability of the soil, and other physical conditions existing at each location at any particular time. Radium-226 and radon are always found with uranium ore and tailings. They produce radiation exposure rates greater than the normal background radiation. Radon contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays, the space component of the natural radiological background, interact in a complicated manner with the elements of the earth's atmosphere and soil. These cosmic ray interactions produce additional background radiation dose rates which vary slightly with latitude and directly with altitude, increasing from 26 mrem/y at sea level in Florida to 107 mrem/y at 10,000 feet above sea level at some

locations in Colorado. The cosmic ray dose rate in Denver, Colorado (one mile above sea level) is about 50 mrem/y.

The aerial survey results include the terrestrial gamma radiation measured throughout the survey area and an estimated cosmic ray exposure rate but excludes the contribution from airborne radon.

4.0 SURVEY BOUNDARIES

The Monticello survey area is located in the southeast corner of Utah in San Juan County. The survey boundary is indicated by a dashed line in Figure 1. This survey area was chosen to incorporate the town of Monticello and the mill site. It extended east of the tailings area approximately 3.5 miles to take into account the drainage of Montezuma Creek and west to the foothills of the Manti-La Sal National Forest.

5.0 SURVEY RESULTS

The results of the aerial survey are presented in Figure 1 as closed contour curves of total gamma radiation exposure rates (iso-radiation contours) in units of μR/h at 3 feet above ground, overlaid on an aerial photograph. These data also include an estimated 7 μR/h cosmic ray contribution.

From a detailed analysis of the data used to prepare Figure 1, natural background radiation exposure rates generally ranged from 14 to 16 μR/h, with scattered locations throughout the survey area fluctuating between 12 and 19 μR/h because of natural changes in terrain and soil composition. The average background total gamma exposure rate in Monticello was 15 μR/h. In Figure 1, background exposure rates are indicated with white contour lines.

The highest radiation exposure rates were observed over the Monticello Mill and tailings area (Figure 1, Area 1). Exposure rates as high as 150 μR/h (approximately 10 times the local background) were observed over the tailings pile.

As indicated in Section 3 of this report, background radiation exposure rates are highly variable. Even for an area as small as the Monticello survey boundary, the soil is not homogeneous. It contains naturally occurring potassium-40, uranium, thorium and their radioactive daughter products in differing amounts. The signature of naturally decaying radium-226 detected with instruments cannot be distinguished from excess radium-226 concentrations in ore or tailings. Therefore, only the relative concentrations and locations of radium-226 provide clues to its origin.

Special data processing helped to identify areas which contained relatively more radium-226 activity than typical background soils. Excess radium-226 activity generally indicates the presence of uranium ore or uranium mill tailings. Data processing details are given in Reference 2. The results of this special analysis have been incorporated into Figure 1 along with the total gamma radiation exposure rates. Those areas with a positive identification of excess radium-226 are indicated with green and blue contour lines.

Area 1 in Figure 1 is the mill and tailings area of Monticello. The activity in this area is a combination of deposition associated with past mill operations and dispersion and deposition associated with wind and water erosion. The tail of Area 1 extending southeast of the mill area is the relatively deep cut creekbed of Montezuma Creek and the major drainage area of the mill and tailings. Area 2 is also located in the

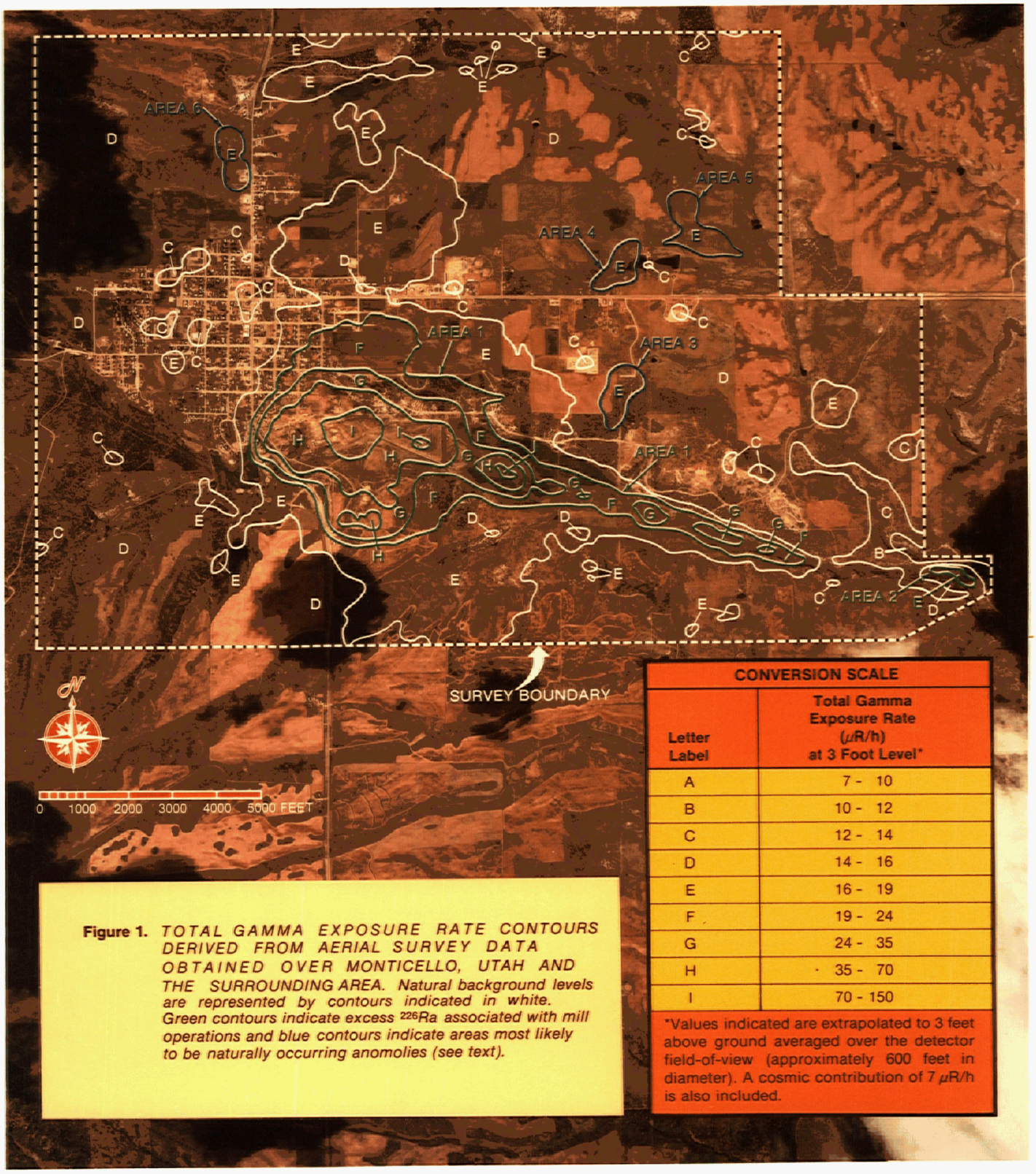
creekbed and probably contains water-eroded tailings associated with past mill operations. Areas 3, 4, 5 and 6 also indicated an excess of radium-226 but in observing their locations in relation to the mill and the terrain they are unlikely locations for materials associated with mill operations and are most likely naturally occurring pockets of increased radium-226 concentration.

It should be noted that the areas in Figure 1 indicating excess radium-226 are not precise boundaries of effected areas. Due to the parameters under which aerial radiological data are collected and processed in some cases the extent of the radium-226 concentrations may extend slightly beyond the area indicated and in others may be well defined and isolated. For example, the "E" contour surrounding Area 1, Figure 1, most likely contains some wind blown tailings material. Therefore, only ground based survey techniques can verify with certainty the precise distribution, concentration and source of radium-226.

REFERENCES

1. Boyns, P.K. July 1976. The Aerial Radiological Measuring System (ARMS): Systems, Procedures, and Sensitivity (1976). Report No. EGG-1183-1691. Las Vegas, Nevada. EG&G

2. Jobst, J.E. 1979. "The Aerial Measuring Systems Program." Nuclear Safety 20:136-47.



CONVERSION SCALE	
Letter Label	Total Gamma Exposure Rate (μR/h) at 3 Foot Level*
A	7 - 10
B	10 - 12
C	12 - 14
D	14 - 16
E	16 - 19
F	19 - 24
G	24 - 35
H	35 - 70
I	70 - 150

*Values indicated are extrapolated to 3 feet above ground averaged over the detector field-of-view (approximately 600 feet in diameter). A cosmic contribution of 7 μR/h is also included.

Figure 1. *TOTAL GAMMA EXPOSURE RATE CONTOURS DERIVED FROM AERIAL SURVEY DATA OBTAINED OVER MONTICELLO, UTAH AND THE SURROUNDING AREA. Natural background levels are represented by contours indicated in white. Green contours indicate excess ^{226}Ra associated with mill operations and blue contours indicate areas most likely to be naturally occurring anomolies (see text).*